Engineering Geology
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Lecture - 40
Identification of Minerals and Rock Samples

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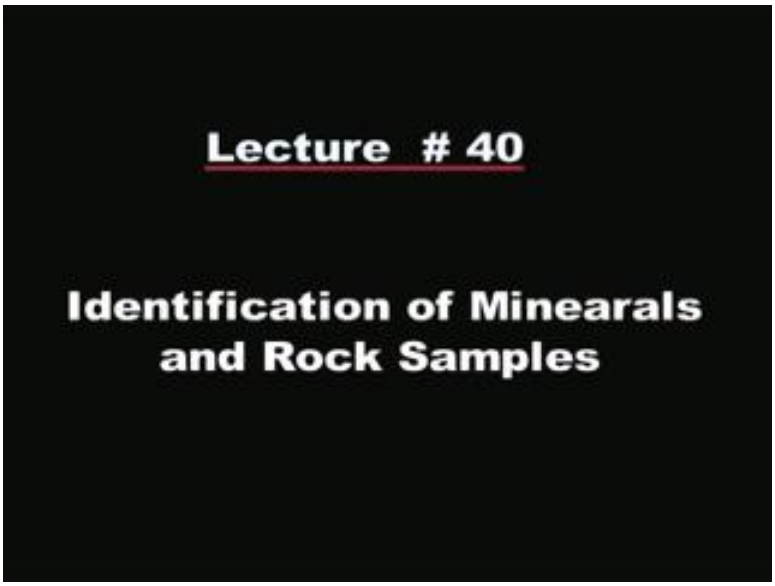

Characteristics of these minerals and rock samples which we discussed earlier in our indoor theory lessons, and today we are going to look at the samples.

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So, first we are going to begin with minerals, common rock forming minerals.

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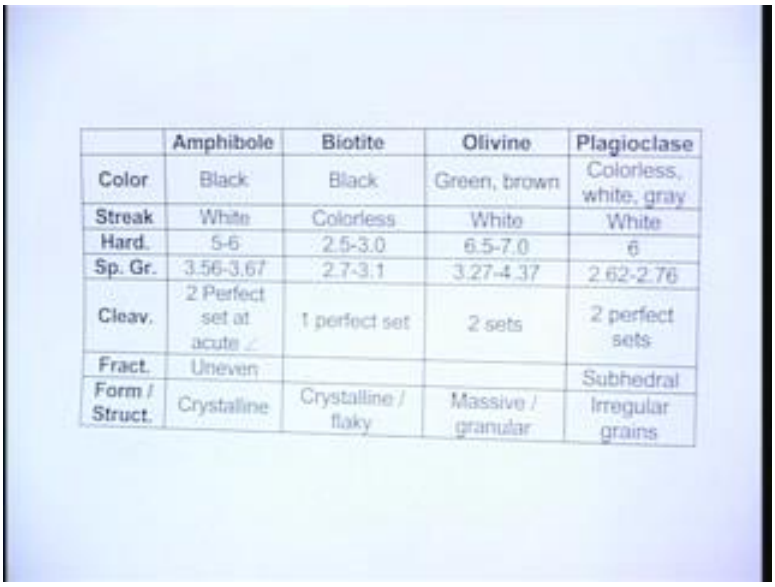

	Amphibole	Biotite	Olivine	Plagioclase
Color	Black	Black	Green, brown	Colorless, white, gray
Streak	White	Colorless	White	White
Hard.	5-6	2.5-3.0	6.5-7.0	6
Sp. Gr.	3.56-3.67	2.7-3.1	3.27-4.37	2.62-2.76
Cleav.	2 Perfect set at acute ∠	1 perfect set	2 sets	2 perfect sets
Fract.	Uneven			Subhedral
Form / Struct.	Crystalline	Crystalline / flaky	Massive / granular	Irregular grains

And if you recall from your classroom lessons, we looked at a few rock forming, a few mafic minerals and few felsic minerals. So, we begin with mafic ones, dark coloured ones; the ones that we talked about in the class were Amphibole, Biotite, Olivine and Plagioclase. Their characteristics, the basic characteristics of these minerals are listed in the table there.

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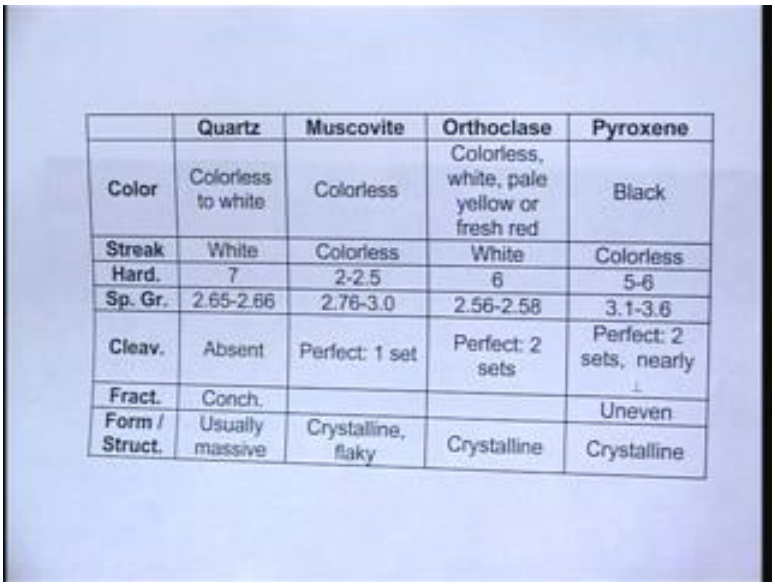

	Quartz	Muscovite	Orthoclase	Pyroxene
Color	Colorless to white	Colorless	Colorless, white, pale yellow or fresh red	Black
Streak	White	Colorless	White	Colorless
Hard.	7	2-2.5	6	5-6
Sp. Gr.	2.65-2.66	2.76-3.0	2.56-2.58	3.1-3.6
Cleav.	Absent	Perfect: 1 set	Perfect: 2 sets	Perfect: 2 sets, nearly ⊥
Fract.	Conch.			Uneven
Form / Struct.	Usually massive	Crystalline, flaky	Crystalline	Crystalline

And then we are going to look at a few felsic minerals and these are the felsic minerals and the properties of these minerals are listed in the table there. So, we are going to look at these minerals one by one. So, let us begin with the mafic minerals. So, here are the common rock forming minerals. We have got seven of them actually. We unfortunately could not get a sample of olivine here, but all the rest of the eight minerals that we talked about, four mafic and four felsic minerals, they are here.

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Now, the first one that I want to show here is an olivine sample. So, the dark coloured portions of this particular piece of rock is olivine and we have got another one here; you can have an look. So, this is one of the dark coloured mafic mineral. Mafic mineral is what we are starting with. And then, the second mineral is the basically Biotite mica and you can see the mica sheets here, and this dark colour mica is called Biotite. So, basic the colour of both Amphibole and Biotite is black as you have seen in the table that we presented earlier to summarize the properties.

Then, we go to plaisio clays. This is a this is a sample of plaisio clays. You can see, you can see that this is basically, basically white coloured mineral and it has got two perfect sets of cleavage here, two perfect sets of cleavage in this particular case, which both of them have got shiny surface. Now, this one we are going to look at the other properties in detail later on, as we continue through the whole demonstration.

The felsic minerals: so, we begin with Quartz and the colour of this one really, just first look at the crystal here. This is a perfect Quartz crystal. So, here what we have got is basically conchoidal cleavage. So, the cleavage, this is a, this is an example of conchoidal, perfect example of conchoidal cleavage, but the colour of this particular thing could vary quite a lot actually.

You could have, typically you should, you are going to get white or colourless Quartz crystal like this one. But on my right hand here is an example of a little bit more uncommon Quartz sample. This one is dark coloured. This is black Quartz, this one.

Now, we are going to go to Muscovite. This is also another mica, a dark coloured, but this one is a light coloured mica. You can see, characteristics are quite same it is both of them are quite flaky. So, this one is, on my right hand I am holding Muscovite, and the Biotite mica that I showed you earlier as a part of felsic minerals mineral group, that is on my left hand. So, you can see and you can compare how they look.

So, then, let us move on to other minerals. We have got, we have got orthoclase basically. These are some examples of Orthoclase and these type of feldspar. You can just look at these, the most common; perhaps the most common colour of this particular mineral is this one. It looks like looks like meat actually; animal flesh. In colour, it is very similar to animal flesh. And if you contrast, if you contrast, actually this one also has got two sets of cleavage, but you should contrast this one with the earlier sample that we showed for another crystal, another feldspar, the plagioclase feldspar which was which is I am holding on my right hand.

And you can see the relative angle between the cleavage, whereas, whereas, both of them have perfect two sets of perfect cleavage. But the orthoclase feldspar, the plains, the cleavage plains, they are inclined at a much slanting angles in comparison with the angle of cleavage that you got, that you normally get, that you get in case of plagioclase.

So, those are the examples of orthoclase and now finally, we are moving onto Pyroxene samples. So, these are also actually dark coloured samples. These are the examples, these are the some examples of Pyroxene mineral and you can have a look at the cleavages and they are black in colour actually. So, dark coloured mineral by definition is not really mafic. So, you could you have seen some of the minerals here are dark coloured, but they are part of the felsic group.

So, that is about all the minerals here. One of the major tools which allow us to differentiate between minerals is the streak and or streak and colour. So, you saw the colour yourself. Now, let us look at the streak of some of these minerals. So, let us look at some other properties of these minerals. Now, one of the tools which allow us to distinguish between different minerals is streak; that together with the colour actually is a very powerful tool which allows us to identify different minerals.

So, let us look at how we are going to get different streaks and the streaks as I mentioned in the class in the indoor lesson earlier, the streak is not the same as colour. So, although you could get a mineral which is dark in colour, you are going, for the same mineral you could, you are, you may actually get white coloured streak. So, let us look at some of the streaks here.

So, let us try the Pyroxene mineral. So, let us start with the Pyroxene minerals. So, this is the Pyroxene mineral that we, the sample of Pyroxene mineral that we have here, which I showed you earlier. So, this has got a dark colour as you can see very easily and this is the streak plate. This is the streak plate used in a mineralogy lab. So, what we are going to do? We are just going to simply rub this particular mineral on top of the streak plate and we are going to observe the colour of the, of what we are going to get on the streak plate. You can see very easily that the colour of the, colour of what we get on the streak plate is basically it has got no colour. So, Pyroxene has got black colour, but colourless streak.

Let us try to get the streak of the orthoclase feldspar. So, this is the sample of orthoclase feldspar which we saw earlier. This one here, it has got a flesh colour. Now, if we if we rub it, we get actually white streak. So, the previous one Pyroxene, we had a colourless streak; we had a colourless streak, but this powder, actually this is the powder that we got when we rubbed the sample of feldspar, but the streak that we get here is of white colour. So, that is the streak for the orthoclase feldspar.

The plagioclase feldspar also if we try, if we try rubbing, if you recall from the table that we presented earlier, if we rub it, rub the sample on streak plate, we are again going to get white colour streak. This is about it, about streak.

We can try we can try Quartz. Let us look at the sample of this sample of dark Quartz. Let us look at the sample of dark Quartz as well as the colourless Quartz; both of them

we are going to look at. Let us see what streak we get out of the dark Quartz. So, let us rub it and here what we get like what we got earlier. We get white coloured streak even when sample is of dark colour. Now, in this particular case of colourless Quartz, again we are going to get a, you just look at it; we are going to get the same coloured streak. So, that is the demonstration on streak; how you determine streak.

Now, let us get to the, get to the, next get to the next property that was listed in the two tables that I gave you earlier and that is hardness. So, if you recall from what I said in the lesson, hardness is basically whether you can actually scratch one particular mineral with another mineral or not. If you can scratch a mineral with the second mineral, the second mineral is harder than the first mineral. And in this process, actually there is a hardness scale that developed that evolved over in the study of mineralogy and we call that particular scale as Mohs scale of hardness.

Now, we are going to look at the minerals that we discussed here and let us look at for instance the list of hardnesses that we are, that we gave, that we listed in the table there. You can see that the hardness here ranges over quite a bit of it has got a very large range really. So, Muscovite has got a hardness of 2 to 2.5 whereas, Quartz has got a hardness of 7. And there are some intermediate values of hardness like Amphibole has got a hardness of 5 to 6. Pyroxene also has got a hardness of 5 to 6.

Now, let us try to see what we mean by this. So, this is the Pyroxene sample that we were showing, that we were seeing earlier. So, this is the Pyroxene sample and I will try to scratch the Pyroxene sample with the sample of Quartz. Quartz has got a hardness of 7 whereas Pyroxene has got a hardness of 5 to 6. Now, let us try to focus on that shiny surface there and I am go to put a scratch mark, try to put a scratch mark on that particular shiny surface with Quartz and hopefully we are going to get a scratch mark when we try to do that, and you can see, you can see now, the scratch mark. So, this is this is the scratch mark that we got from trying to scratch the Pyroxene sample with Quartz. And since we could put a scratch mark on the Pyroxene sample using Quartz and Quartz has a got hardness of 7, so, we know that Pyroxene has got a hardness of less than 7.

Now, let us try another thing. Plagioclase has got a hardness of 6. So, let us and let us see what I have (( )) do here. Muscovite actually has got a hardness of 2.5 to 3. So, we

should be able to put a scratch mark on Muscovite with the sample of Pyroxene that we scratched with the Quartz specimen. So, let us look at that. So, we are going to focus on the shiny surface there and what we are going to do is difficult, but we are going to try to scratch put a scratch mark on this particular shiny surface using the Pyroxene sample, and you can see that this is the scratch mark. You can see that this is the scratch mark that we put on the sample of mica using Pyroxene; using the Pyroxene sample.

So, this particular one here has got a hardness of less than 5; that we can say. This is actually a Muscovite mica; sample of muscovite mica. So, what else? We can try here. We have already discussed about cleavage. I talked about one sets of cleavage and two sets of cleavage. So, this one, let us look at let us look at what I mean. So, this one here, this is the Pyroxene sample once again. So, this is an example of perfect cleavage. This is an example of perfect cleavage, this one.

Now, Quartz on the other hand, it has, this one has got, this is not, these are not cleavage plane actually. This is an example of there is no cleavage actually in this one in case of Quartz basically. What else? Amphibole sample: In case of Amphibole sample also we have got perfect cleavage. You can (( )) on to these dark coloured pieces; minerals. So, this is also another example of perfect cleavage.

All these things Biotite, Amphibole, Amphibole as well as Pyroxene has got basically two sets of cleavage, but Biotite mica and muscovite mica has got one set of cleavage because of the fact that these things are flaky in nature. So, I can actually get the flakes out. You can try to focus on that and see the flaky nature of these minerals. You can see that I can easily get the flakes out from these minerals, and the same with the case in case of in case of muscovite mica as well. In fact, some of the flakes are coming out, coming out from this thing and coming into my hand. Let me see whether I can get some flakes out of this. So, cleavage actually has got ... So, that is those are the flakes that are coming out. So, you can see that they are really very thin sheets that composes the rock mass.

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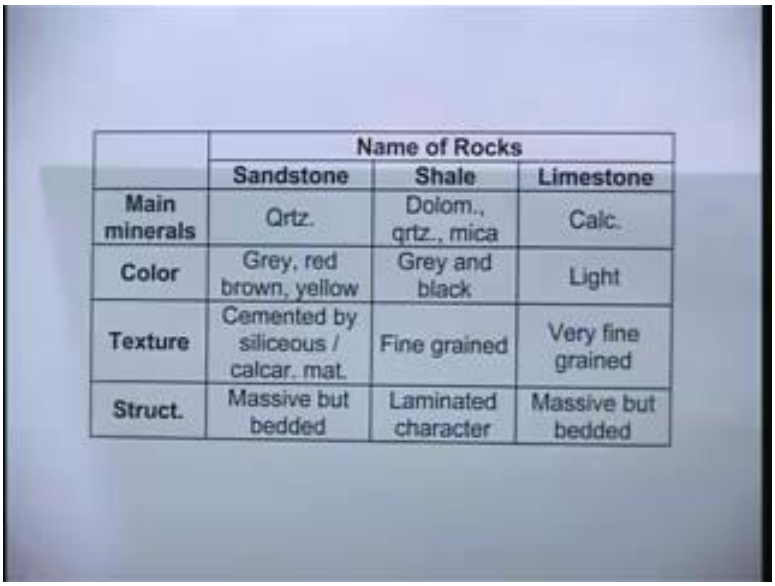

	Name of Rocks		
	Sandstone	Shale	Limestone
Main minerals	Qrtz.	Dolom., qrtz., mica	Calc.
Color	Grey, red brown, yellow	Grey and black	Light
Texture	Cemented by siliceous / calcar. mat.	Fine grained	Very fine grained
Struct.	Massive but bedded	Laminated character	Massive but bedded

Now we are going to look at a few samples of common type of, common rock types. Let us begin with the sedimentary rocks. We are going to look at a few samples of sandstone, shale and limestone. We also I also included a sample of conglomerate here because that you will see the variety of different types of class or different types of constituents that are present in a mass of conglomerate because that might be also of interest. So, what we have here, these are actually the sample; the cases.

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What you should really look at is the indication of sedimentation, really. For example, this one here, this one the big piece here is a sample of limestone and if you look at it this is a very heavy one really. If you look at it, you can see the layers in which the Calcite was Calcite mineral was deposited in forming the rock mass. So, the layer type of structure, layered structure really is a hall mark of essentially all different types of sedimentary rocks.

So, this is actually a piece of limestone. You can see that it is extremely difficult really to distinguish individual grains of this particular type of rock. So, it is a fine grained rock. Now, here there are a few pieces of sandstone and sandstone can really vary a lot in terms of the grain size that composes the rock mass, and colour also could vary quite a bit. For example, this one is a yellow colour sandstone and you try to look at the grains of this particular rock mass. It is really visible to naked eye and it has got a rough feeling when you run your finger on top of the rock mass here. And some of these, this one on the other hand, this one, this piece here is pink in colour and you can see the deposition, The signatures of deposition environment here on those lines there and this particular piece came out of a single beading of a sandstone. So, you do not really see those distinct clearing that we saw earlier in case of the limestone sample.

Now, this pink sample here is much smoother to feel, smoother in feel in comparison with this yellow sandstone piece. Now, you have got another gray piece of sandstone

here. This one is even coarser in feel in comparison with the piece of yellow sandstone and this one is quite fiable actually. So, if I rub the surface of this particular sample, then pieces of sand is going to come out of the mass of the sandstone. You can see that I just rub my finger on the sandstone and this is what I got on my hand. Actually sandstone could be quite fiable and it will be very difficult to distinguish if the sandstone is fiable and weathered. So, from a mass of sand, from a mass of dense sand, it will be very difficult to distinguish. Although there will be there could be some cementation, but in case of fiable sandstones, the signature of cementation, actually the effect of cementation could be quite less.

Third sample that we are going to look at, third sample that we have here is a sample of shale, and this is again once again what you see here is that layered structure and this is another one really. You can see that the signatures of the deposition of the environment as well as the which is which is evident from the layering, layered structure that we have here.

Now, another thing that I want to point out here is that if you recall what we discussed in in our class room lesson earlier on this topic, clays actually clay minerals, when they lithify, rock form out of clay minerals. Then you get you get what is called clay stone or shale. So, this is an example of clay stone or shale.

So, here, these things are extremely fine in granularities. So, individual grains will be impossible to detect by naked eye. You can if you focus on the on a small portion of the surface of this rock mass, then you can convince yourself that it is extremely difficult actually to distinguish individual grains of these this rock and that is quite in contrast with what we saw earlier in case of the sandstone. So, this is another piece of rock of fine grained, composed basically of fine grained particle.

Finally, let us look at in this group what we have got? We have got piece of we have got a couple of pieces of conglomerates and these are essentially results of cementation of individual preexisting pieces of rock and you can see that is very clearly visible here. So, for example, that was a preexisting rock fragment which got cemented by cementitious material and this cementitious material could be could be a calcareous cement or any other type of cement, silica cement or any other type of cement. Then what forms in the process is a piece of rock, is a mass of rock and that is called conglomerates. So, it is an

extremely variable type of rock in terms of grain sizes of the constituents. This is one example and that is another example of a conglomerate.

So, let us now move onto the second class of rocks. We are going to start with, we started with sedimentary rocks and now we are going to move on to igneous rocks. Although I think I think we should have really started with the igneous rock, but the way these are placed on the table, so it was convenient for me to start with the sedimentary rock. So, now let us move on to the igneous rock.

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Finally, we are going to come to the metamorphic rocks.

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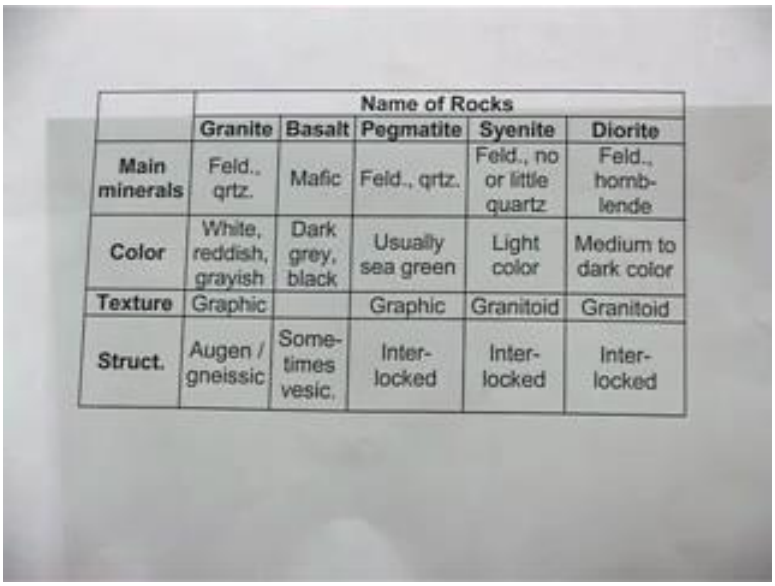

	Name of Rocks				
	Granite	Basalt	Pegmatite	Syenite	Diorite
Main minerals	Feld., qrtz.	Mafic	Feld., qrtz.	Feld., no or little quartz	Feld., hornb-lende
Color	White, reddish, grayish	Dark grey, black	Usually sea green	Light color	Medium to dark color
Texture	Graphic		Graphic	Granitoid	Granitoid
Struct.	Augen / gneissic	Some-times vesic.	Inter-locked	Inter-locked	Inter-locked

Now, we are into igneous rocks. So, their origin is basically volcanism or actually cooling of magma really. So, a few common types of types of igneous rocks are listed here and in addition to these rocks, we have got an example of a volcanic glass as well obsidian in this particular group. So, just look at the basic characteristics of these types of rocks and then we are going to take a few samples in order to illustrate all these things.

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So, let us begin with granite and what we have got really. This is actually a structure. The structure of granite is called a graphic structure and this is really an interlocking interlocked arrangement of individual grains, individual crystals, and you can see for instance that there is a crystal, crystal of there are crystals of feldspar, light coloured and fleshy colour really.

There are pink, pinkish crystals of feldspar and some dark colour minerals in between and these crystals really are quite large and you can see the individual grains in case of granite. So, granite is basically an example of coarse grained volcanic rock. As I explained in the class in earlier in one of the earlier lesson is that because of the fact that granite cools at a much slower rate, the crystals have got a chance of growing to much larger size as opposed to a piece of basalt; the one that I am holding in my left hand, the dark colour specimen. And you can see that in this particular case, the cooling rate was much faster and as a result individual grains the crystal growth is much more muted and the crystals, the individual grains are much finer.

At the other extreme, the extreme, the other extreme of this thing, this is an intermediate case really; so, this is at one extreme you could say. At the extreme rapid rate of cooling what you get is a thing like this. This is a sample of volcanic glass. So, this is actually after the volcanic eruption, the rock forming minerals, they cool at a at such a fast phase that crystal growth is not is not possible.

So, what you get is instead of a crystalline structure, you get a glass like mass, like the one that I am holding here on my left arm, the dark coloured shiny piece, this is called this type of rock is called obsidian, obsidian which is by the way not included in the table that we were showing just a little bit back. So, this is an example of obsidian.

So, you can see, you have seen the structure of a granite. This type of structure is also called and augen type of structure in which you can augen means eye basically. So, it looks, it gives an appearance of an eye really. So, there are different between the dark colour and the light colour. So, this is an example of granite.

Then, this is another one and basically a Biotite granite, and you can see this is this is quite a bit different actually in comparison with the previous example of granite that we were considering. So, granite really is not a single type of rock. There could be a wide variety of granite in terms of in terms of coarseness of the mineral crystals as well as in

terms of its mineral mineralogical constituent. The one that I am holding in the front, towards you actually, towards the camera is an example of Biotite granite. This is a much lighter in appearance in comparison with the previous one which is a more common variety of granite; pinkish granite, pink granite.

Here you can see the Biotite mineral within the rock mass; this one here that I am pointing right now is a essentially a Biotite mineral that we saw earlier. So, these are the two samples of granite. This is an example of diodite. So, this one here is composed. The light coloured background is really you can see that this is also, it has got two colours in it; a light coloured background, light coloured mineral as well as a dark coloured mineral. Typically the light coloured mineral is the feldspar and the dark coloured mineral in this case is hornblend and this one here is much lighter in comparison with the granite rock that we were considering earlier.

And actually another thing that I want to point out here is that the graininess in individual grains or individual crystals in this particular case is much finer in comparison with granite that we saw earlier. In fact, the second sample of granite was much finer grained than the first sample of granite. So, this one here is an example of ceanite. Again we have got feldspar with little or no Quartz in this particular case. So, this is pinkish. The light coloured background is once again feldspar and there are some mafic minerals. You can see there are quite a view mafic minerals in this particular rock mass as well.

What else? We have got another piece here which is a Pegmatite. This one is a pegmatite and here this structure is again quite similar to what we saw earlier and here again we have got interlocked crystalline structure in which all the individual crystals, they are really interlocked and here again we have got quite a bit of Biotite mica as are evident within the rock here.

Otherwise, these are basically Biotite pieces of Biotite mica. Let me see whether we can see, if you look at it you can see that the flake. I could easily deflake this particular I mean this is the piece here. So, this is pegmatite and now let us we are going to move on to metamorphic rocks.

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Now, finally we are into the group, into the metamorphic group of rocks and again we are going to these are these are this table here has got a list of few common types of metamorphic rocks and we are going to look at some of them.

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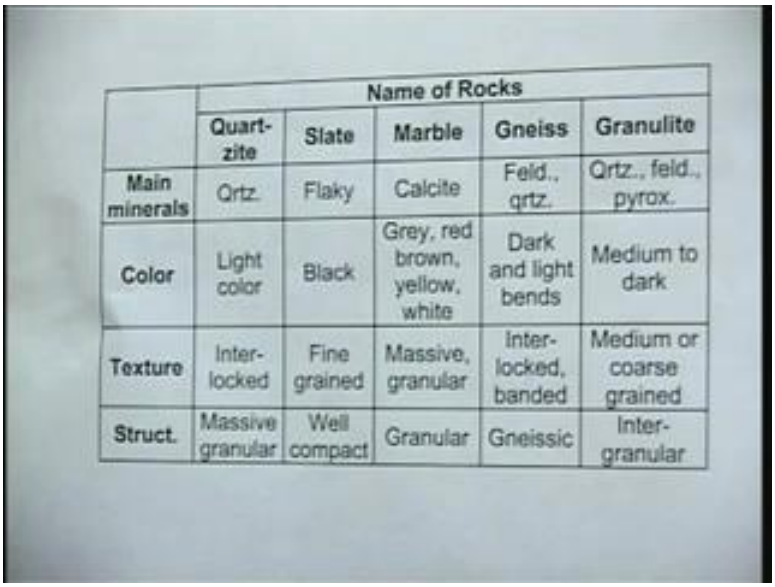

	Name of Rocks				
	Quart-zite	Slate	Marble	Gneiss	Granulite
Main minerals	Qrtz.	Flaky	Calcite	Feld., qrtz.	Qrtz., feld., pyrox.
Color	Light color	Black	Grey, red brown, yellow, white	Dark and light bends	Medium to dark
Texture	Inter-locked	Fine grained	Massive, granular	Inter-locked, banded	Medium or coarse grained
Struct.	Massive granular	Well compact	Granular	Gneissic	Inter-granular

Now, metamorphic rocks, as we have seen from our earlier lesson, they could form from metamorphism because of pressure increase or because of temperature driven processes from both igneous rocks as well as sedimentary rocks and we are going to look at some of those rocks.

For instance we saw earlier, we, I pointed out earlier that marble is a kind of metamorphic rock that forms out of metamorphism of limestone. Similarly, we also saw that gneiss is another type of metamorphic rock that forms out of metamorphism of a granite. We are going to look at that in the next little bit.

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So, these are basically some of the metamorphic rocks. Now, this one here is an example of gneiss which is listed on the table that we were showing a little bit, just a little bit little while ago. You can see that you can see the layered appearance known as gneissic structure really. This is actually goes by the name gneissic structure from this particular sample and in fact, gneiss is a type of rock that forms out of the metamorphism of granite. So, basically this was the starting point really. This was the starting point and you can see that all the individual grains and grains and crystals; they are haphazardly aligned.

Now, when this type of rock is subjected with huge amount of pressure, then minerals tend to get aligned in a particular direction depending on the direction of pressure and what you get is a gneissic appearance, as is evident from this particular sample here.

You can see the haphazard arrangement of grains and you can see the ordered appearance that is there on the sample on my left hand the sample of gneiss and that is because of the intense pressure that the original rock mass was subjected to. So, this is gneiss.

Another type of very similar, another type of rock of very similar characteristic is a granulite and that is this one here. So, this one I mean constitutionally granulite is very similar to gneiss, but it has got quite a bit of mafic mineral in it. In fact, the mafic minerals that is abundant in this one among those is the Pyroxene mineral. Otherwise this particular thing, this particular sample is quite similar; structurally speaking, this quite similar to the sample of gneiss that we considered earlier.

Another difference actually, slight difference actually, this one is slightly coarse grained. You can see the granularity of this one. It is slightly coarser grained in comparison with the gneiss sample; sample of gneiss that we were looking at earlier. Then that is a type of metamorphism we looked at.

Now, let us look at another metamorphic rock and this is slate; this one here is a slate and slate the starting point of slate, you can see the flaky nature of the sample. Thin sheet like appearance of the sample and taken very relatively easily the individual sheets can be separated although it is going to be little bit more difficult. Deflaking the micas is little bit more difficult, but still the flakes can be easily, relatively easily, they can be separated.

So, this is, if you recall from what we discussed in the class, I mean slate is a type of rock that arises from metamorphism of shale. So, this is the type of rock that was the beginning of this metamorphic rock. So, this is the beginning, and finally what you get is this one here and this is also more often this is also is because of metamorphism, because of pressure related metamorphism. So, this is sample of slate.

Now, another one. This is a piece of marble is quite this is slightly granular in nature. You can try to, you can you can try to focus on it and it is going to tell you that the structure of this one is granular, in which you can actually see some of the individual grains of Calcite and I will if you recall from what we discussed earlier is that marble forms because of metamorphism of limestone.

So, what we began with is this piece here; the metamorphism of this particular one which I am holding on my left hand. This is the starting point of this of formation of marble. So, this is the beginning and the end product of the metamorphism the process of metamorphism is this one, and marble is much more compact generally in comparison with limestone.

Another one here is Quartzite. So, this is actually an example of Quartzite and the primary constituent of Quartzite is Quartz. Quartzite forms from the basically Quartzite forms from metamorphism of sandstone. So, what we have here is this; this was a piece of sandstone, pink sandstone that we looked at earlier; so, this was the starting point and this is the end product of the process of metamorphism. So, what you this this kind (( )) because we actually could compare different types of rocks, metamorphic rocks and we could see that they are related very closely to a parent rock mass which underwent a certain type of physical process that gave rise to some change in structure, which led to a totally different type of rock, the class of rock called metamorphic rocks and we saw a certain a number of samples metamorphic rock.

So, with that said actually we are towards the end of the demonstration in which we looked at a few a samples of rock and a few samples of common rock forming minerals. We looked at some of the characteristics, easily determinable characteristics of the minerals which allow us to roughly identify some of these minerals and distinguish them from other minerals.

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So, with that we are going to wrap up this demonstration. Then, we are at the final little bit of this particular course.

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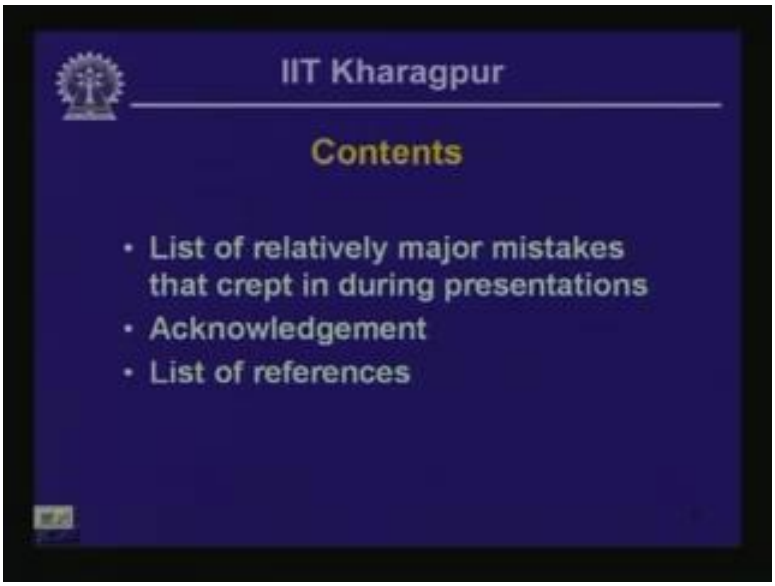

In order to wrap up, I am just going to going to list some of the mistakes that crept into our presentations which you have already looked at unfortunately so that you could correct your notes accordingly. I am going to have a list of acknowledgements and I am going to wrap things up with a list of references which you could read at your leisure and you will find the information in those list of references, in those references useful for improving your understanding about the subject.

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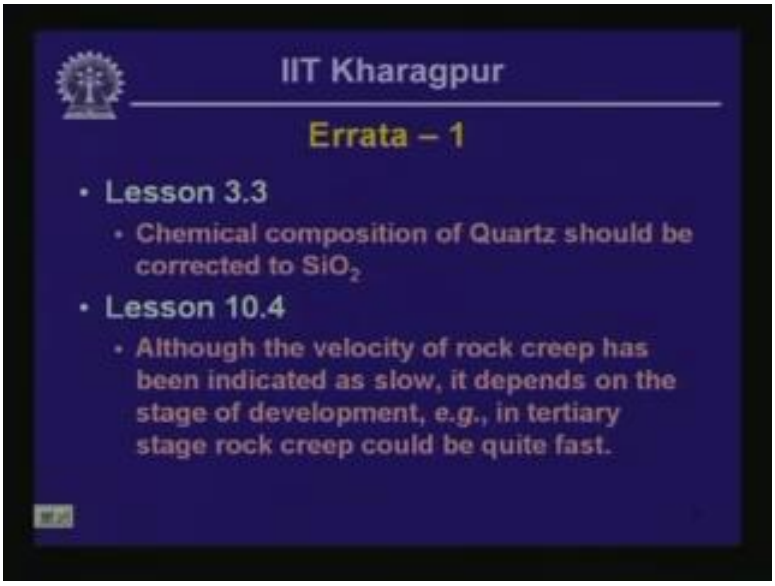

You should note these errors that crept in. We noticed these errors as a part of the review process. In lesson 3.3 chemical composition of Quartz was indicated as SIO 4; it should actually be SIO 2. Then, in lesson 10.4, we indicated, I indicated that the rock creep is generally slow, but you should note that the creep, the speed of rock creep depends on the stage really as to how matured your process is. So, if there, if the rock creep process is at the tertiary stage, then the speed could in fact be quite high. So, you should correct your notes from lesson 10.4 to consider this point.

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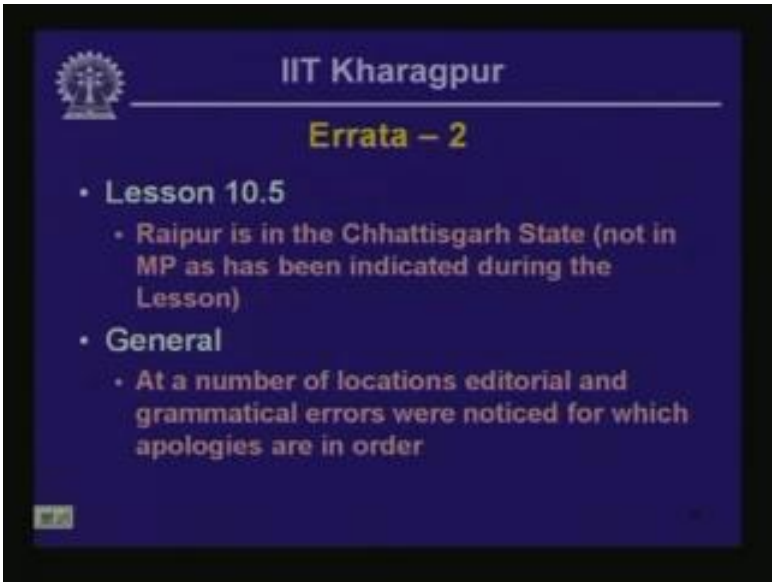

Then lesson 10.5 by mistake we indicated that Raipur is a part of Madhya Pradesh, but in fact, it is part of the newly formed, relatively newly formed Chhattisgarh state. And finally, there were a number of editorial and grammatical errors for which I and those errors I did not list here, but I must apologise for those errors in the notes, and I think you would be able to notice those errors and correct your notes because they are quite obvious although they did not, to my understanding, affect the technical content of this particular course.

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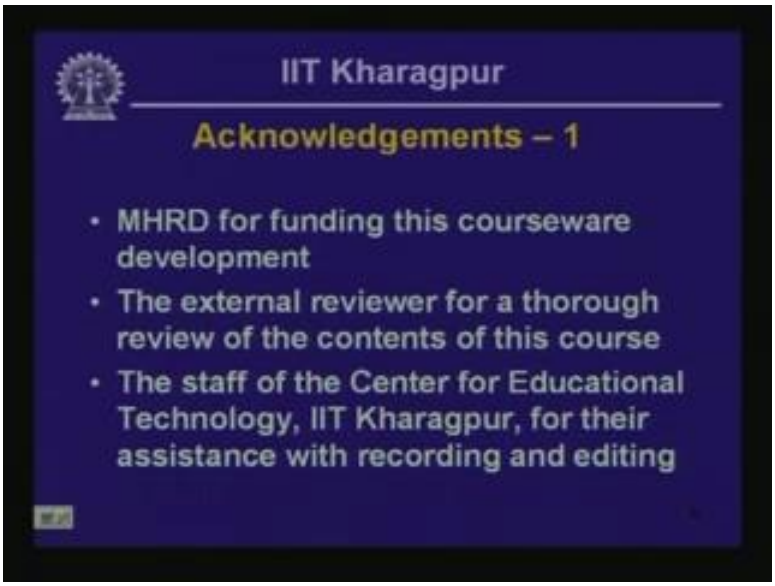

Now, to the list of acknowledgements; this course was, this courseware was prepared in the NPTEL project of founded by the MHRD for which I am grateful. Then external reviewer actually made a very thorough review of this, of the contents of the technical contents of this course and in fact, the errors or the mistakes that I listed earlier where largely came out during the review process itself and I am grateful to the external reviewer for the thorough review.

Thirdly, the staff of the Center for Educational Technology, IIT Kharagpur helped me out with the preparation of this course. They provided an excellent back drop which made possible this entire development. I am grateful for their help and they also in fact did comment about the review and the visual appearance of this particular course. That is also very useful in qualitative improvement of this particular courseware.

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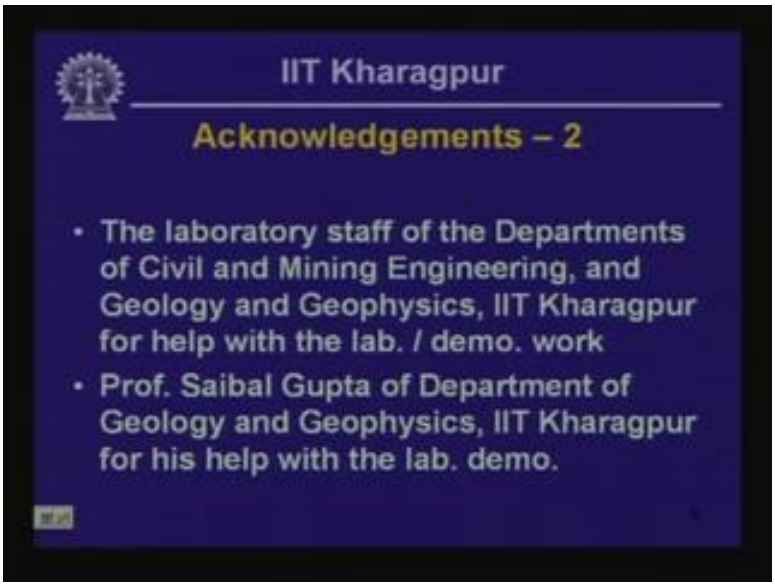

Laboratory staff of the Departments of Civil, Mining, Civil and Mining Engineering and the Department of Geology and Geophysics of IIT Kharagpur provided help with the laboratory and demonstration work which formed the majority of the last three lessons of this particular course. Particularly, Professor Saibal Gupta of Department of Geology and Geophysics; he was instrumental in developing the lab program of the concerning the mineralogical and petrological assessment of rock and mineral samples. I am grateful for his help.

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I am also grateful to my students who helped me with various parts of the courseware development; particularly, Raghvendra Singh, Amit Gupta, Debaditya Dutta, Pawan Kumar, Sanjeev Kumar and Lakeswar Laguri.

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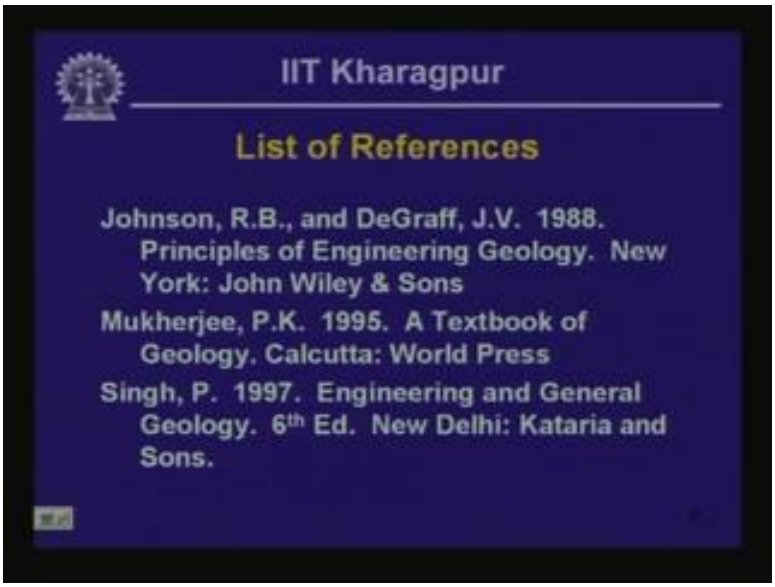

Finally, I need to list some of the general references that might be useful in order to enhance your knowledge regarding Engineering Geology. Needless to say that the course that I tried to prepare here was by no means complete; so, it has to be the knowledge provided here needs to be supplemented from reading other papers or text books.

Some of the general text books are listed here: The first one, Principles of Engineering Geology; this particular text book I found that it contained useful information regarding geohazard index, testing soil or rock subsurface investigation of soil and rock sides. It has also got very useful information on remote sensing applications in Engineering Geology. The second reference: A Text book of Geology - this particular one has very good information on mineralogical, regarding mineralogy and petrology of rock and mineral samples. It also has got very useful information regarding geologic map preparation and section preparation and all those stuff which we discussed in the last little bit of this particular course.

And thirdly, the book by Prabin Singh Engineering and General Geology; this also could be a very useful reference. It has got a wealth of information regarding structural geology, regarding false and folds, and other features that we discussed in the early part

of this course. It has also got information regarding Mineralogy, Crystallography. All those details also we discussed in the early part of this course.

And you need to discuss the topics with your teachers as the time comes because the information that is provided here has to be supplemented, as I mentioned earlier, with other sources because the because no courseware can be a self-contained repository of all knowledge as that there could be on the topics cover.

I just wanted to provide you with the glimpse of the subjects that are generally of that are generally interest in Engineering Geology. And if you need to interact with me, by all means you should try to contact me through IIT Kharagpur and provide me your comments or questions. During the interaction I would also be glad to provide you with my inputs on your thoughts or your problems.

Thank you very much.